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(54) Frame synchronization system among multiple radio base stations for TDMA digital mobile communication system.

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ELECTRONICS & COMMUNICATIONS IN JAPAN,vol. 67, no. 10, October 1984, pages 39-47; S. SAKATA et al.: "A PCM-TDMA one dimensional mobile communication system using leaky coaxial cables"

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Description

The present invention relates to a digital mobile communications system wherein mobile stations and a control station communicate via radio base stations each being located in a particular service area on a TDMA (Time Division Multiple Access) basis. More particularly, the present invention is concerned with a frame synchronization method among the radio base stations.

A TDMA digital mobile communications system of the type described usually has a control station and a plurality of radio base stations each being located in a particular service area. A number of mobile stations mounted on motor vehicles, for example, each communicates with the control station via one of the radio base stations existing in the service area where the mobile station itself is located, by using an assigned carrier and an assigned time slot.

When a given mobile station moves from a first service area covered by a first radio base station to a second service area covered by a second radio base station, it will communicate with the control station via the second radio base station thereafter.

Assume that when the mobile station moves as stated above, TDMA frame synchronization has not been established between the first and second radio base stations and the communication of the mobile station has to be handed over to the second radio base station. Then, the mobile station has to set up frame synchronization with the second radio base station before restarting the communication. To set up frame synchronization rapidly, TDMA frame generators installed in the individual radio base stations for generating TDMA frames may be reset at the same time.

Resetting a plurality of TDMA frame generators simultaneously as mentioned above may be implemented with a satellite which sends a reset signal to the individual radio base stations. Specifically, on receiving the reset signal, each radio base station resets the TDMA frame generator thereof for setting up frame synchronization. Such a system, however, is large scale and not practical since it needs not only a satellite but also a reset signal transmitter mounted on the satellite and a receiver built in each radio base station for receiving the reset signal from the satellite.

Thus, it has been difficult to set up frame synchronization among radio base stations without scaling up the system. Every time handover occurs, a mobile station has to set up frame synchronization with the TDMA frames being transmitted from a radio base station located in the new service area. Voice is interrupted until such frame synchronization has been established.

In IEEE INT. CONF. ON COMMUNICATIONS, Seattle, Washington, 7th - 10th June 1987. vol. 1, pages 327-331, IEEE, New-York, US; M.A. LATTORE et al.: "SMD 30/1'5: An advanced PMP TDMA radio system with powerful operation and maintenance facilities", a point to multipoint TDMA radio communication system is described.

In ELECTRONICS & COMMUNICATIONS IN JAPAN, vol. 67, no. 10, October 1984, pages 39-47; S.SAKATA et al.: "A PCM-TDMA one dimensional mobile communication system using leaky coaxial cables", a TDMA mobile communication system is disclosed in which base stations have delay compensation.

It is therefore an object of the present invention to provide a frame synchronization method among a plurality of radio base stations for a TDMA digital mobile communication system which prevents voice from being interrupted when a mobile station moves from one service area to another.

A TDMA frame synchronization system among a plurality of radio base stations of the present invention has a single control station governing a plurality of service areas, a plurality of radio base stations each being situated in respective one of the service areas and each having a TDMA frame generator, and a plurality of mobile stations each being freely movable from one service station to another and a cable of interchanging digital signals with a particular radio base station situated in the service area where it is located. The system has synchronous signal generating means for transmitting a reset pulse for resetting the TDMA frame generators, and delaying means for delaying the transmitted reset pulse to cause it to reach all the radio base stations subordinate to the control station at the same time. The reset pulse outputted by the delaying means is applied to the TDMA frame generator of each radio base station. The reset pulse is sent every TDMA frame.

The delaying means has returning means for receiving the reset pulse and returning it immediately to the synchronous signal generating means as a return pulse. The synchronous signal generating means has time delay determining means for detecting a time when the return pulse is received and, on the basis of a period of time defined by the time when the reset pulse is transmitted and the time when it is received, determining a set time delay of the delaying means.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other objects, features and advantages of the present invention will become more apparent by reference to the following detailed description of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a block diagram schematically showing a frame synchronization system embodying the present invention;

Fig. 2 shows a condition wherein TDMA frames being sent from nearby radio base stations are

not synchronous;

Fig. 3 shows a condition wherein TDMA frames being sent from nearby radio base stations are synchronous;

Fig. 4 is a diagram showing a positional relation of the control station and radio base stations to one another;

Fig. 5 is a chart demonstrating how a set time delay of each time delay adjustment unit is determined;

Fig. 6 is a block diagram schematically showing a specific construction of a control station;

Fig. 7 is a block diagram schematically showing a specific construction of a synchronous signal generator unit;

Fig. 8 is a block diagram schematically showing a specific construction of a radio base station;

Fig. 9 is a block diagram showing a specific construction of a time delay adjustment unit; and

Fig. 10 is a block diagram schematically showing a specific construction of a mobile station.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1 of the drawings, a TDMA mobile communications system has a single control station 1 which governs a plurality of service areas. In the figure, the service areas are represented by two service areas 2-a and 2-b for illustration. Radio base stations 3-a and 3-b are situated in the service areas 2-a and 2-b, respectively, to cover the associated areas. Communication cables 4-a and 4-b connect respectively the radio base stations 3-a and 3-b to the control station 1. Among a number of mobile stations, a given mobile station 5 holds a digital mobile communication with the control station 1 via the radio base station residing in the service area in which the mobile station 5 is located, e.g., the radio base station 3-a of the service area 2-a by using an assigned carrier and an assigned time slot. The mobile stations may be a portable type or a vehicle-mounted type.

When the mobile station 5 moves from the service area 2-a to the service area 2-b during communication, the communication is handed over to allow the mobile station 5 to communicate with the control station 1 via the radio base station 3-b situated in the service area 2-b, instead of the base station 3-a.

As shown in Fig. 2, assume that at the time of the hand-over the TDMA frames (represented by three frames A1, B1 and C1) being sent from the radio base station 3-a and the TDMA frames (represented by A2, B2 and C2) being sent from the radio base station 3-b are not synchronous. Then, the mobile station 5 entered the service area 2-b has to set up frame synchronization with the radio base station 3-b before restarting the communication. The frame synchronization causes the frames A1, B1 and C1 from the radio base station 3-a and the frames A2, B2 and C2 from the radio base station 3-b to coincide with each other, as shown in Fig. 3. For the frame synchronization, TDMA frame generators each being installed in respective one of the radio base stations 3 (here, 3-a and 3-b) as will be described have to be reset to cause the transmission times of the frames from the individual TDMA frame generators into coincidence to less than the time in which a guard bit preceding each of the frames exists (eight bits; about 25 microseconds). During the frame synchronization, the communication is interrupted. Such interruption may reach 46 milliseconds, for example, under the GSM (Groupe Special Mobile) Recommendations due for launch in Europe in July 1991, because the Recommendations require a synchronization signal to be transmitted once in ten frames each of which has a time duration of 4.6 milliseconds.

In the embodiment shown in Fig. 1, a synchronous signal generator unit 6 is located in the vicinity of the control station 1, but it may be installed in the station 1. Time delay adjustment units 7-a and 7-b are situated in the vicinity of and connected to the radio base stations 3-a and 3-b, respectively. The units 7-a and 7-b may also be installed in the base stations 3-a and 3-6, respectively. The synchronous signal generator unit 6 and time delay adjustment units 7-a and 7-b cooperate to set up frame synchronization between the TDMA signals which the radio base stations 3-a and 3-b send. The synchronous signal generator unit 6 has a synchronous pulse generator 11 and a time delay processor 12. The time delay adjustment units 7-a and 7-b each has a down-link signal delay circuit 13 and an up-link signal delay circuit 14. The synchronous signal generator unit 6 is respectively connected to the radio base stations 3-a and 3-b by communication cables 15-a1 and 15-a2 and 15-b1 and 15-b2 and time delay adjustment units 7-a and 7-b.

The operation of the embodiment regarding the synchronous signal generator unit 6 and time delay adjustment units 7-a and 7-b will be outlined. The synchronous pulse generator 11 sends one pulse (transmission pulse) per TDMA frame for frame synchronization. The time delay adjustment units 7-a and 7-b each returns the transmission pulse as first and second return pulses, respectively, as will be described. On detecting the first and second return pulses, the time delay processor 12 determines first and second intervals between the transmission of the transmission pulse and the detection of the first and second pulses, respectively. With the first and second intervals, it is possible to determine first and second time delays between the control station 1 and the radio base stations 3-a and 3-b, respectively. It is to be noted that most of the time delays is ascribable to the communication cables 15-a1, 15-a2, 15-b1 and 15-b2 or the communication cables 4a and 4b which

are equivalent to the former. First and second set time delays to be set in the time delay adjustment units 7-a and 7-b, respectively, are calculated and then set in the units 7-a and 7-b. The time delay adjustment units 7-a and 7-b are manually or automatically controled to set time delays thereof on the basis of the first and second set time delays, respectively, by the down-link signal delay circuit 13 and up-link signal delay circuit 14. This will be described in detail later. As a result, the time delay adjustment units 7-a and 7-b delay a down-link signal and an up-link signal.

A reference will now be made to Figs. 3 and 5 for explaining how time delays between the control station 1 and a plurality of radio base stations 3 (represented by base stations 3-a and 3-b) are measured and how additional time delays for resetting a plurality of TDMA frame generators at the same time are set.

To begin with, a procedure for measuring a time delay between the control station 1 and a given radio base station 3 will be described. As shown in Fig. 4, assume that the synchronous signal generator unit 6 adjoining the control station 1 is located at a point O, the radio base station 3-a and the associated time delay adjustment unit 7-a are located at a point A, and the radio base station 3-b and the associated time delay adjustment unit 7-b are located at a point B. Referring also to Fig. 5, the procedure for setting the time delay of the point A, i.e., the time delay adjustment unit 7-a begins with a step of setting the time delays of the down-link and up-link signal delay circuits 13 and 14 to zero. Then, the synchronous pulse generator 11 (point O) sends a transmission pulse, and this pulse is applied to the down-link signal delay circuit 13 (point A). The transmission pulse is returned from the up-link signal delay circuit 14 to the time delay processor 12 (point O) as a return pulse, as indicated by a dashed line in Fig. 5. The interval t_a between the transmission of the transmission pulse and the detection of the return pulse is the reciprocation time delay between the points O and A (mainly ascribable to the communication cables 15-a1 and 15-a2). In the same manner, a reciprocation time delay t_b between the points O and B is determined by detecting a return pulse from the time delay adjustment unit 7-b.

How additional time delays (set time delays) are set in the time delay adjustment units 7 will be described. In order for the radio base stations 3-a and 3-b to set up frame synchronization, an arrangement should only be made such that the transmission pulse sent from the synchronous pulse generator 11 reaches the base stations 3-a and 3-b at the same time. For this purpose, time delays are set by a specific procedure as will be described. The periods of time in which the time delay processor 12 receives return pulses from the time delay adjustment units 7-a and 7-b as measured from the time when the synchronous pulse generator 11 sent a transmission pulse both are set to be T (open to choice). An arrangement is made such that in a given time delay adjustment unit 7 the down-link and up-link signal delay circuits 13 and 14 have the same set time delay, and that a transmission pulse arrives at any of the radio base stations 3 in a period of time of T/2. Specifically, the time delay processor 12 determines a first set time delay ($T-t_a$) and a second set time delay ($T-t_b$) associated with the radio base stations 3-a and 3-b, respectively, on the basis of the measured time delays t_a and t_b. The so determined set time delays ($T-t_a$) and ($T-t_b$) are provided to the control station 1 which in turn transmits these time delays ($T-t_a$) and ($T-t_b$) to the base stations 3-a and 3-b through the communications lines 4-a and 4-b, respectively. The time delays ($T-t_a$) and ($T-t_b$) may be displayed on a display, not shown, which may be provided on the synchronous pulse generator unit 6. The time delays ($T-t_a$) and ($T-t_b$) may also be respectively reported to the radio base stations 3-a and 3-b by telephone or similar implementation. In response to the time delays, the radio base stations 3-a and 3-b set the set time delays in the associated time delay adjustment units 7-a and 7-b. In the time delay adjustment unit 7-a, a time delay of $(T-t_a)/2$ is set in each of the down-link and up-link signal delay circuits 13 and 14. Likewise, in the time delay adjustment unit 7-b, a time delay of $(T-t_b)/2$ is set in each of the down-link and up-link signal delay circuits 13 and 14.

In the above condition, a transmission pulse from the synchronous pulse generator 11, i.e., a pulse sent from the point O is delayed by ($T-t_a$) at the point A, delayed by ($T-t_b$) at the point B, and then inputted as a return pulse to the point O, i.e., the time delay processor 12 in the time T.

The signal delay circuits 14 each is rendered inoperative as soon as the set time delay is set in the associated time delay adjustment unit 7-a or 7-b.

Once the set time delays are set in the individual time delay adjustment units 7-a and 7-b as stated above, a transmission pulse from the synchronous signal generator unit 6 arrives at the radio base stations 3-a and 3-b at the point P shown in Fig. 5, i.e., in the period of time of T/2 with no regard to the lengths of the communications cables 4 interconnecting the control station 1 and radio base stations 3. The radio base stations 3 each uses the arrived transmission pulse for resetting a timing pulse generator thereof. As a result, the mobile station is capable of establishing synchronization among the TDMA frames being transmitted from all of the radio base stations 3 instantaneously.

Referring to Fig. 6, a specific construction of the control station 1 will be described. As shown, the control station 1 is connected at one signal terminal to a public switching telephone network (PSTN) 21 and at the other signal terminals to the radio base stations 3-a and 3-b. A switching circuit 41 which is connected

to a central processing unit (CPU) 44 governing the entire control station 1, performs the switching operation with respect to the mobile station 5. The switching circuit 41 is connected at one signal terminal to the PSTN 21 and at the other signal terminals to trunk circuits 42 and 43. The trunk circuits 42 and 43 are respectively connected to the radio base stations 3-a and 3-b by the communications cables 4-a and 4-b so as to transform signal codes into a transmission format which is agreed upon by the control station 1 and radio base stations 3-a and 3-b beforehand.

When the reciprocation time delays t_a and t_b are measured, the CPU 44 controls the base stations 3-a and 3-b to return a transmission pulse as a return pulse. At the time of setting the set time delays in the time delay adjustment units 7-a and 7-b, the CPU 44 sequentially sends to the base stations 3-a and 3-b the set time delays with control signals causing the base stations 3-a and 3-b to set the time delays in the units 7-a and 7-b, respectively.

The hand-over of communication that occurs after the time delays have been set in the time delay adjustment units 7-a and 7-b will be described with reference to Figs. 1 and 6. When the mobile station 5 is located in the service area 2-a, it holds a communication while setting up frame synchronization with the radio base station 3-a. In this condition, the switching circuit 41 of the control station 1 is connected to the trunk circuit 42. As the mobile station 5 approaches the service area 2-b, its communication is handed over from the service area 2-a to the service area 2-b and the station 5 starts communicating with the radio base station 3-b. At this instant, the switching circuit 41 is caused into connection with the trunk circuit 43. Since the time delay of the reset pulse (frame synchronizing pulse) between the control station 1 and the base station 3-a and the time delay of the reset pulse between the control station 1 and the base station 3-b are substantially equal, the mobile station 5 sets up frame synchronization with the base station 3-b immediately. Hence, the mobile station 5 can start communicating with the radio base station 3-b without the voice being interrupted.

It is noteworthy that the set time delays need only to be set once before the start of operation of the radio base stations 3 and do not have to be adjusted despite any possible changes in the communication conditions.

Fig. 7 shows a specific construction of the synchronous signal generator 6. As shown, the synchronous signal generator 6 has a signal generator 71 for generating a clock, and a counter 72 which divides the frequency of the clock to produce pulses whose period corresponds to one TDMA frame. A buffer circuit 73 converts the signal level of the output pulses of the counter 72 and delivers sequentially the resulting pulses to a plurality of down-link signal delay circuits 13 which are connected to the radio base stations. A buffer circuit 74 sequentially receives pulses (return pulses) coming in over a plurality of up-link signal delay circuits 14 which are also connected to the radio base stations 3. A counter 75 is reset by the output pulses of the counter 72 and counts time on the basis of the clock fed from the signal generator 71. A latch circuit 76 receives the time counted by the counter 75 and latches it in response to a pulse signal from the buffer circuit 74. The latched time is written to the CPU 44 of the control station 1. The signal generator 71, counter 72 and buffer circuit 73 constitute the synchronous pulse generator 11 while the buffer circuit 74, counter 75 and latch circuit 76 constitute the time delay processor 12.

A major function assigned to the synchronous signal generator unit 6 is to generate synchronous signal pulses (transmission pulses) having a one TDMA frame period and sending them to the time delay adjustment units 7. Another major function is to measure the delay times (pulse propagation times) between itself and the time delay adjustment units 7 on the basis of the pulse returned from the units 7 and to provide the results of measurement to the CPU 44 of the control station 1.

Fig. 8 shows a specific construction of the radio base station 3. As shown, the radio base station 3 has a trunk circuit 51 connected to the control station 1, a burst control circuit 52, a transceiver 53 connected to the burst control circuit 52, an antenna 54 connected to the transceiver 53 for transmitting and receiving a radio signal from the mobile station 5, a CPU 55 circuit for supervising the entire base station 3, a timing pulse generator 56, and a signal generator 57 for outputting a clock. The burst control circuit 52 transforms a voice signal from the trunk circuit 51 and signaling from the CPU 55 into burst pulses in response to timing pulses which are generated by the timing pulse generator 56, the burst pulses fed to the transceiver 53. A signal sent from the mobile station 5 and coming in through the antenna 54 is delivered to the trunk circuit 51 and CPU circuit 55 via the burst control circuit 52. The timing pulse generator 56 generates TDMA timing pulses in response to the clock from the signal generator 57. The timing pulse generator 56 is reset by a reset pulse (transmission pulse) sent from the synchronous signal generator 6 via the down-link delay circuit 13 and a terminal 303, whereby a plurality of radio base stations 3 are synchronized with respect to TDMA frames. The timing pulse generator 56 and burst control circuit 52 in combination play the role of the previously stated TDMA frame generator.

The CPU 55 is also connected to the delay adjustment unit 7 via a terminal 302 to control the unit 7. More specifically, the CPU 55 causes the unit 7 to return a transmission pulse to the synchronous signal generator unit 6 at the time of measuring the reciprocation time delay t_a or t_b. When the set time delay is set, the CPU 55 sets the set time delay in the unit 7

in response to the control signal from the control station 1.

Referring to Fig, 9, a specific construction of the time delay adjustment unit 7 having the down-link signal delay circuit 13 and up-link signal delay circuit 14 is shown. The down-link signal delay circuit 13 has a latch circuit 81 in which the CPU 55 of the associated radio base station 3, for example, writes a set time delay. A buffer circuit 82 receives a transmission pulse from the synchronous pulse generator 11. A switch 83 is connected to the buffer circuit 82 at one end thereof and under the control of CPU 55. A flip-flop 84 has a set input terminal to which a pulse from the buffer circuit 82 is applied. A signal generator 85 generates a clock. A counter 86 is reset by an output of the flip-flop 84 and counts time on the basis of the clock. A comparator 87 compares the increasing output of the counter 86 with the constant output of the latch circuit 81 and, when they coincide, produces a pulse. The output pulse of the comparator 87 is applied as a reset pulse to the reset input terminal of the flip-flop 84 and the timing pulse generator 56 of the associated radio base station 3. At the same time, the output pulse or the comparator 87 is fed to the up-link signal delay circuit 14 as a return pulse.

The up-link signal delay circuit 14 has a buffer circuit 88 which is connected to the other end of the switch 83 for returning a transmission pulse fed from the buffer circuit 82 to the synchronous pulse generator 11. This circuit 14, like the circuit 13, has a latch circuit, flip-flop, signal generator counter, and comparator, although not shown in the figure. On receiving the reset pulse or return pulse from the comparator 87 of the circuit 13, the circuit 14 delays it by a set time delay and sends the delayed pulse as a return pulse via the buffer circuit 88.

A major function of the time delay adjustment unit 7 is to return, at the time of measurement of a reciprocation time delay between the control station 1 and the radio base station 3, a transmission pulse from the synchronous signal generator 6 by way of the buffer circuits 82 and 88 and switch 83. Another major function is to delay a transmission pulse from the buffer circuit 82 by a set time delay and sending the delayed transmission pulse to the timing pulse generator 56 of the base station 3 via the comparator 87. Still another major function is to delay a transmission pulse from the comparator 87 by a set time delay and sending the delayed pulse as a return pulse to the time delay processor 12 which is connected to the output of the up-link signal delay circuit 14.

When a transmission pulse is applied to the flip-flop 84 of the time delay adjustment unit 7 via the buffer circuit 82, the counter 86 is set and starts counting the clock from the signal generator 85 while inputting the count to the comparator 87. The time delay measured at the time of time delay setting stage is stored in the latch circuit 81 beforehand by, for example, the CPU 55 of the radio base station 7. The comparator 87 compares the value of the latch circuit 81 and that of the counter 86 and, when they coincide, outputs a pulse. This pulse resets the TDMA timing pulse generator 56 of the base station 3 and the counter 86 via the flip-flop 84.

As shown in Fig. 10, the mobile station 5 has an antenna 61 for transmitting and receiving TDMA signals from the radio base stations 3-a and 3-b over electro-magnetic waves. The antenna 61 is connected to a transceiver 62 which is in turn connected to a burst control circuit 63. A handset 64 is connected to the burst control circuit 63 and interfaces the user to the mobile station 5. A timing pulse generator 65 is also connected to the burst control circuit 63. A CPU 66 is connected to the burst control circuit 63 and timing pulse generator 65 for supervising the entire mobile station 5. A signal generator 67 generates a clock. The burst control circuit 63 transforms a voice signal from the handset 64 and the signaling from the CPU 66 into bursts (frames) in response to timing pulses which are fed thereto from the timing pulse generator 65. These bursts are delivered to the transceiver 62. A signal sent from the mobile station 5 and come in through the antenna 61 is fed to the handset 64 and CPU 66. The timing pulse generator 65 generates TDMA timing pulses in response to the clock from the signal generator 67. The CPU 66 controls the timing pulse generator 65 in response to the TDMA frame synchronizing signals being sent from the radio base stations 3, thereby setting up frame synchronization between signals received from the base stations 3.

In summary, in accordance with the present invention, each radio base station has a time delay adjustment unit while a synchronous pulse generator is located in close proximity to a control circuit. The time delay adjustment units of the individual radio base stations delay a transmission pulse, or frame synchronizing pulse, sent from the synchronous pulse generator such that the pulse arrives at all of the base stations at the same time. This allows TDMA frame generators installed in the individual radio base stations to be reset at the same time, insuring TDMA frame synchronization among the base stations. Hence, a mobile station does not have to set up frame synchronization every time it is handed over from one service area to another. As a result, rapid hand-over of a mobile station is promoted, and the momentary cut-off of a signal is eliminated.

Claims

1. A TDMA digital mobile communications system comprising a control station (1), a plurality of radio base stations (3-a) each being located in respective one of service areas (2-a) which are governed by said control station and each com-

prising a TDMA frame generator (56), and a plurality of mobile stations (5) each being movable in said service areas while interchanging digital signals with said radio base stations located in said service areas by using an assigned time slot, characterized by

synchronous signal generating means (6) for transmitting a reset pulse for resetting the TDMA frame generators;

delaying means (7) for delaying said transmitted reset pulse, and inputting said delayed reset pulse to associated one of said radio base stations; and

means for applying said reset pulse inputted from said delaying means to associated one of said TDMA frame generators, wherein a time delay assigned to each of said delaying means (1) varies with a distance between said radio base station (3-a) and said control station (1) and is selected such that said reset pulse delayed by all of said radio base stations is inputted to all of said radio base stations at the same time wherein said delaying means (7) comprises returning means (14) for receiving said reset pulse and returning said reset pulse as a return pulse to said synchronous signal generating means (6), and wherein said synchronous signal generating means (6) comprises time delay determining means (12) for detecting a first time when said return pulse is received and, on the basis of a period of time defined by a second time when said reset pulse is transmitted and said first time when said reset pulse is received, determining a time delay of said reset pulse.

2. A system as claimed in claim 1, wherein said reset pulse is transmitted every TDMA frame.

3. A system as claimed in claim 1 or 2, wherein said synchronous signal generating means (6) comprises:

signal generator means (71) for generating a clock;

first counter means (72) for dividing a frequency of said clock to generate said reset pulse having a period of one TDMA frame and transmitting said reset pulse to said delaying means;

second counter means (75) reset by said reset pulse fed from said first counter means for measuring a period of time until said return pulse of said reset pulse transmitted from said delaying means arrives by using said clock; and

latch circuit means (76) for latching said period of time measured by said second counter means.

4. A system as claimed in claim 1, 2, or 3 wherein said delaying means comprises:

latch circuit means (81) to which a set time delay is written via a set input terminal thereof;

flip-flop means (84) having a set input terminal for receiving said reset pulse;

signal generator means (85) for generating a clock;

counter means (86) reset by an output of said flip-flop means for counting time by using said clock signal; and

comparator means (87) for comparing the output of said latch circuit means and the output of said counter means and, when said outputs coincide, outputting a reset pulse while feeding said reset pulse to said flip-flop means as a reset pulse and to said radio base station as an output.

5. A system as claimed in claim 1 or 2, wherein

said synchronous signal generating means (6) is situated near or in said control station said delaying means is situated near or in said radio base stations,

said synchronous signal generating means comprises:

signal generator means (71) for generating a clock;

first counter means (72) for dividing a frequency of said clock signal to generate said reset pulse having a period of one TDMA frame;

second counter means (75) reset by said reset pulse outputted by said first counter means (72) for measuring a period of time from said resetting to arrival of a return pulse of said reset pulse by using said clock; and

latch circuit means (76) for latching said period of time measured by said second counter means;

said delaying means comprises:

latch circuit means (81) to which a set time delay is written via a set input terminal thereof;

flip-flop means (84) having a set input terminal for receiving a pulse signal;

signal generator means (85) for generating a clock;

third counter means (86) reset by an output of said flip-flop means for counting time by using said clock; and

comparator means (87) for comparing the output of said latch circuit means and the output of said third counter means and, when said outputs coincide, outputting a delayed pulse signal by delaying said pulse signal by said set time delay and feeding said delayed pulse signal to said flip-flop means (84) as a reset pulse and to said radio base station as an output pulse.

6. A system as claimed in claim 5, wherein said reset pulse generated by said synchronous signal generating means (6) is applied to said set input

terminal of said flip-flop means (84) over a communications cable (15-a1, 15-a2), said output pulse produced by delaying said reset pulse being applied to said synchronous signal generating means over said communications cable.

Patentansprüche

1. Digitales, mobiles TDMA (Mehrfachzugriff im Zeitmultiplex)-Kommunikationssystem mit einer Steuerstation (1), mehreren Funkbasisstationen (3-a), die sich jeweils in einem der Anschlußbereiche (2-a), die von der Steuerstation aus gesteuert werden, befinden und von denen jede einen TDMA-Rahmengenerator (56) aufweist, und mehreren mobilen Stationen (5), die jeweils während des Austauschs von Digitalsignalen mit den innerhalb der Anschlußbereiche befindlichen Funkbasisstationen mit Hilfe eines zugeordneten Zeitschlitzes innerhalb der Anschlußbereiche beweglich sind, gekennzeichnet durch eine Einrichtung (6) zum Erzeugen synchroner Signale zur Übertragung eines Rückstellimpulses zum Rückstellen der TDMA-Rahmengeneratoren,
eine Verzögerungseinrichtung (7) zum Verzögern des übertragenen Rückstellimpulses und zur Eingabe dieses verzögerten Rückstellimpulses in die dazugehörige Funkbasisstation, und
eine Einrichtung zum Zuführen des von der Verzögerungseinrichtung eingegebenen Rückstellimpulses zu dem dazugehörigen TDMA-Rahmengenerator,
wobei die jeder Verzögerungseinrichtung (7) zugeordnete Zeitverzögerung mit der Entfernung zwischen der Funkbasisstation (3-a) und der Steuerstation (1) variiert und so gewählt wird, daß der von allen Funkbasisstationen verzögerte Rückstellimpuls an alle Funkbasisstationen gleichzeitig gesendet wird,
wobei die Verzögerungseinrichtung (7) eine Rückgabeeinrichtung (14) zum Empfang des Rückstellimpulses und zur Rückgabe des Rückstellimpulses als Rückgabeimpuls an die Einrichtung (6) zum Erzeugen synchroner Signale aufweist, und wobei die Einrichtung (6) zum Erzeugen synchroner Signale eine Zeitverzögerungsbestimmungseinrichtung (12) zur Bestimmung eines ersten Zeitpunkts, wenn der Rückgabeimpuls empfangen wird und, basierend auf einer Zeitspanne, die durch einen zweiten Zeitpunkt beim Übertragen des Rückstellimpulses und den ersten Zeitpunkt bei Empfang des Rückstellimpulses definiert ist, zur Bestimmung einer Zeitverzögerung des Rückstellimpulses, aufweist.

2. System nach Anspruch 1, wobei der Rückstellimpuls pro TDMA-Rahmen übertragen wird.

3. System nach Anspruch 1 oder 2, wobei die Einrichtung (6) zum Erzeugen synchroner Signale aufweist:
eine Signalerzeugungsreinrichtung (71) zum Erzeugen eines Takts,
eine erste Zähleinrichtung (72) zum Teilen der Taktfrequenz zum Erzeugen des Rückstellimpulses mit einer Periode von einem TDMA-Rahmen und zur Übertragung dieses Rückstellimpulses an die Verzögerungseinrichtung,
eine zweite Zähleinrichtung (75), die durch den von der ersten Zähleinrichtung gelieferten Rückstellimpuls zurückgestellt wird, um mit Hilfe des Takts eine Zeitspanne zu messen bis der von der Zeitverzögerungseinrichtung übertragene Rückgabeimpuls des Rückstellimpulses ankommt, und
eine Speichereinrichtung (76) zum Speichern der von der zweiten Zähleinrichtung gemessenen Zeitspanne.

4. System nach Anspruch 1, 2 oder 3, wobei die Verzögerungseinrichtung aufweist:
eine Speichereinrichtung (81), in die über einen Einstellanschluß davon eine eingestellte Zeitverzögerung eingeschrieben wird,
eine Flip-Flop-Einrichtung (84) mit einem Einstellanschluß für den Empfang des Rückstellimpulses, eine Signalerzeugungseinrichtung (85) zum Erzeugen eines Takts,
eine Zähleinrichtung (86), die durch ein Ausgabesignal der Flip-Flop-Einrichtung zur Zeitbestimmung mittels eines Taktsignals zurückgestellt wird, und
eine Vergleichseinrichtung (87) zum Vergleich des Ausgabesignals der Speicherschaltung mit dem Ausgabesignal der Zähleinrichtung und, wenn die Ausgabesignale gleich sind, zum Ausgeben eines Rückstellimpulses während der Rückstellimpuls zur Flip-Flop-Einrichtung als Rückstellimpuls und zur Funkbasisstation als Ausgabesignal zugeführt wird.

5. System nach Anspruch 1 oder 2, wobei
die Einrichtung (6) zum Erzeugen synchroner Signale sich nahe der oder innerhalb der Steuerstation befindet,
die Verzögerungseinrichtung sich nahe der oder innerhalb der Funkbasisstationen befindet,
die Einrichtung zum Erzeugen synchroner Signale aufweist: einen Signalgenerator (71) zum Erzeugen eines Takts,
einen ersten Zähler (72) zum Teilen einer Frequenz des Taktsignals zum Erzeugen des Rückstellimpulses mit einer Periode von einem TDMA-Rahmen,
einen zweiten Zähler (75), der durch den von dem ersten Zähler (72) ausgegebenen Rückstellim-

puls zurückgestellt wird, um eine Zeitspanne vom Zurückstellen bis zur Ankunft eines Rückgabeimpulses des Rückstellimpulses mit Hilfe des Takts zu messen, und
einen Speicher (76) zum Speichern der von dem zweiten Zähler gemessenen Zeitspanne,
wobei die Verzögerungseinrichtung aufweist:
einen Speicher (81), in dem über einen Einstellanschluß davon eine eingestellte Zeitverzögerung eingeschrieben wird,
eine Flip-Flop-Einrichtung (84) mit einem Einstellanschluß für den Empfang eines Impulssignals, einen Signalgenerator (85) zum Erzeugen eines Takts, einen dritten Zähler (86), der durch ein Ausgabesignal der Flip-Flop-Einrichtung zur Zeitbestimmung mittels eines Taktsignals zurückgestellt wird, und
eine Vergleichseinrichtung (87) zum Vergleich des Ausgabesignals des Speichers mit dem Ausgabesignal des dritten Zählers, und, wenn die Ausgabesignale gleich sind, zum Ausgeben eines verzögerten Impulssignals durch Verzögern des Impulssignals mittels der eingestellten Zeitverzögerung und zum Zuführen dieses verzögerten Impulssignals zur Flip-Flop-Einrichtung (84) als Rückstellimpuls und zur Funkbasisstation als Ausgabesignal.

6. System nach Anspruch 5, wobei der von der Einrichtung (6) zum Erzeugen synchroner Signale erzeugte Rückstellimpuls über ein Kommunikationskabel (15-a1, 15-a2) dem Einstellanschluß der Flip-Flop-Einrichtung (84) zugeführt wird, wobei der durch eine Verzögerung des Rückstellimpulses erzeugte Ausgabeimpuls über das Kommunikationskabel der Einrichtung zum Erzeugen synchroner Signale zugeführt wird.

Revendications

1. Système de communication mobile numérique TDMA comprenant une station de contrôle (1), une pluralité de stations de base radio (3-a) dont chacune est localisée dans une zone de service (2-a) particulière, qui sont gérées par ladite station de contrôle et dont chacune comporte un générateur (56) de trame TDMA et une pluralité de stations mobiles (5) dont chacune est mobile dans lesdites zones de service, tout en échangeant des signaux numériques avec lesdites stations de base radio localisées dans lesdites zones de service en utilisant un créneau temporel assigné, caractérisé par :

   des moyens (6) générateurs d'un signal de synchronisation pour transmettre une impulsion de réinitialisation pour réinitialiser les générateurs de trame TDMA,

   des moyens de retard (7) pour retarder ladite impulsion de réinitialisation transmise, et pour entrer ladite impulsion de réinitialisation retardée sur l'une associée desdites stations de base radio ; et

   des moyens pour appliquer ladite impulsion de réinitialisation entrée par lesdits moyens de retard à l'un associé desdits générateurs de trame TDMA ;

   dans lequel un retard temporel assigné à chacun desdits moyens de retard (7) varie avec la distance entre ladite station de base radio (3-a) et ladite station de contrôle (1) et est sélectionné de sorte que ladite impulsion de réinitialisation retardée par l'ensemble desdites stations de base radio est entrée sur l'ensemble desdites stations de base radio en même temps,

   lesdits moyens de retard (7) comportent des moyens de retour (14) pour recevoir ladite impulsion de réinitialisation et retourner ladite impulsion de réinitialisation comme impulsion de retour sur lesdits moyens (6) générateurs de signal de synchronisation, et dans lequel lesdits moyens (6) générateurs de signal de synchronisation comportent des moyens (12) de détermination de retard temporel pour détecter un premier instant quand ladite impulsion de retour est reçue et, sur la base d'une période de temps définie par un second instant, quand ladite impulsion de réinitialisation est transmise, et par le dit premier instant quand ladite impulsion de réinitialisation est reçue, déterminant un retard temporel de ladite impulsion de réinitialisation.

2. Système selon la revendication 1, dans lequel ladite impulsion de réinitialisation est transmise à chaque trame TDMA.

3. Système selon la revendication 1 ou 2, dans lequel lesdits moyens (6) générateurs de signal de synchronisation comportent :

   des moyens (71) générateurs de signal pour générer une horloge ;

   des premiers moyens (72) de comptage pour diviser la fréquence de ladite horloge pour générer ladite impulsion de réinitialisation et une période d'une trame TDMA et transmettant ladite impulsion de réinitialisation auxdits moyens de retard ;

   des seconds moyens de comptage (75) réinitialisés par ladite impulsion de réinitialisation fournie par lesdits premiers moyens de comptage, pour mesurer une période de temps jusqu'à ce que ladite impulsion de retour de ladite impulsion de réinitialisation transmise par lesdits moyens de retard, arrivent en utilisant ladite horloge ; et

   des moyens (76) de circuit de mémorisa-

tion pour maintenir ladite période de temps mesurée par lesdits seconds moyens de comptage.

4. Système selon les revendications 1, 2 ou 3 dans lequel lesdits moyens de retard comportent :
   des moyens de circuit de mémorisation (81) sur lesquels on écrit un retard temporel à charger via une borne d'entrée de chargement ;
   des moyens bascules (84) comportant une borne d'entrée de chargement pour recevoir ladite impulsion de réinitialisation ;
   des moyens (85) générateur de signal pour générer une horloge ;
   des moyens de comptage (86) réinitialisés par une sortie desdits moyens bascules pour compter le temps en utilisant ledit signal d'horloge ; et
   des moyens comparateurs (87) pour comparer la sortie desdits moyens de circuit de mémorisation et la sortie desdits moyens de comptage et, quand lesdites sorties coïncident, pour produire en sortie une impulsion de réinitialisation tout en fournissant ladite impulsion de réinitialisation auxdits moyens bascules comme impulsion de réinitialisation et auxdites stations de base radio comme sortie.

5. Système selon les revendications 1 ou 2, dans lequel lesdits moyens (6) générateurs de signal de synchronisation sont situés prés de ou dans ladite station de contrôle,
   lesdits moyens de retard sont situés près de ou dans lesdites stations de base radio,
   lesdits moyens générateurs de signal de synchronisation comportent :
   des moyens (71) générateurs de signal pour générer une horloge ;
   des premiers moyens de comptage (72) pour diviser la fréquence dudit signal d'horloge pour générer ladite impulsion de réinitialisation présentant une période d'une trame TDMA ;
   des seconds moyens (75) de comptage, réinitialisés par ladite impulsion de réinitialisation produite en sortie desdits premiers moyens (72) de comptage, pour mesurer une période de temps allant de ladite réinitialisation jusqu'à l'arrivée d'une impulsion de retour de ladite impulsion de réinitialisation en utilisant ladite horloge ; et
   des moyens (76) de circuit de mémorisation pour maintenir ladite période de temps mesurée par lesdits seconds moyens compteurs ;
   lesdits moyens de retard comportent :
   des moyens de circuit de mémorisation (81) sur lesquels on écrit un retard temporel à charger via une borne d'entrée de chargement ;
   des moyens (84) bascules comportant une borne d'entrée de chargement pour recevoir un signal impulsionnel ;
   des moyens (85) générateurs de signal pour générer une horloge ;
   des troisièmes moyens de comptage (86) réinitialisés par une sortie desdits moyens bascules pour compter une durée en utilisant ladite horloge ; et
   des moyens comparateurs (87) pour comparer la sortie desdits moyens bascules et la sortie desdits troisièmes moyens de comptage et, quand lesdites sorties coïncident, pour produire en sortie un signal impulsionnel retardé en retardant ledit signal impulsionnel dudit retard temporel et pour fournir ledit signal impulsionnel retardé auxdits moyens bascules (84) comme impulsion de réinitialisation et à ladite station de base radio comme impulsion de sortie.

6. Système selon la revendication 5, dans lequel ladite impulsion de réinitialisation générée par lesdits moyens (6) générateurs de signal de synchronisation est appliquée à ladite borne d'entrée desdits moyens bascules (84) par un câble de communications (15-a1, 15-a2), ladite impulsion de sortie produite en retardant ladite impulsion de réinitialisation étant appliquée auxdits moyens générateurs de signal de synchronisation par ledit câble de communications.

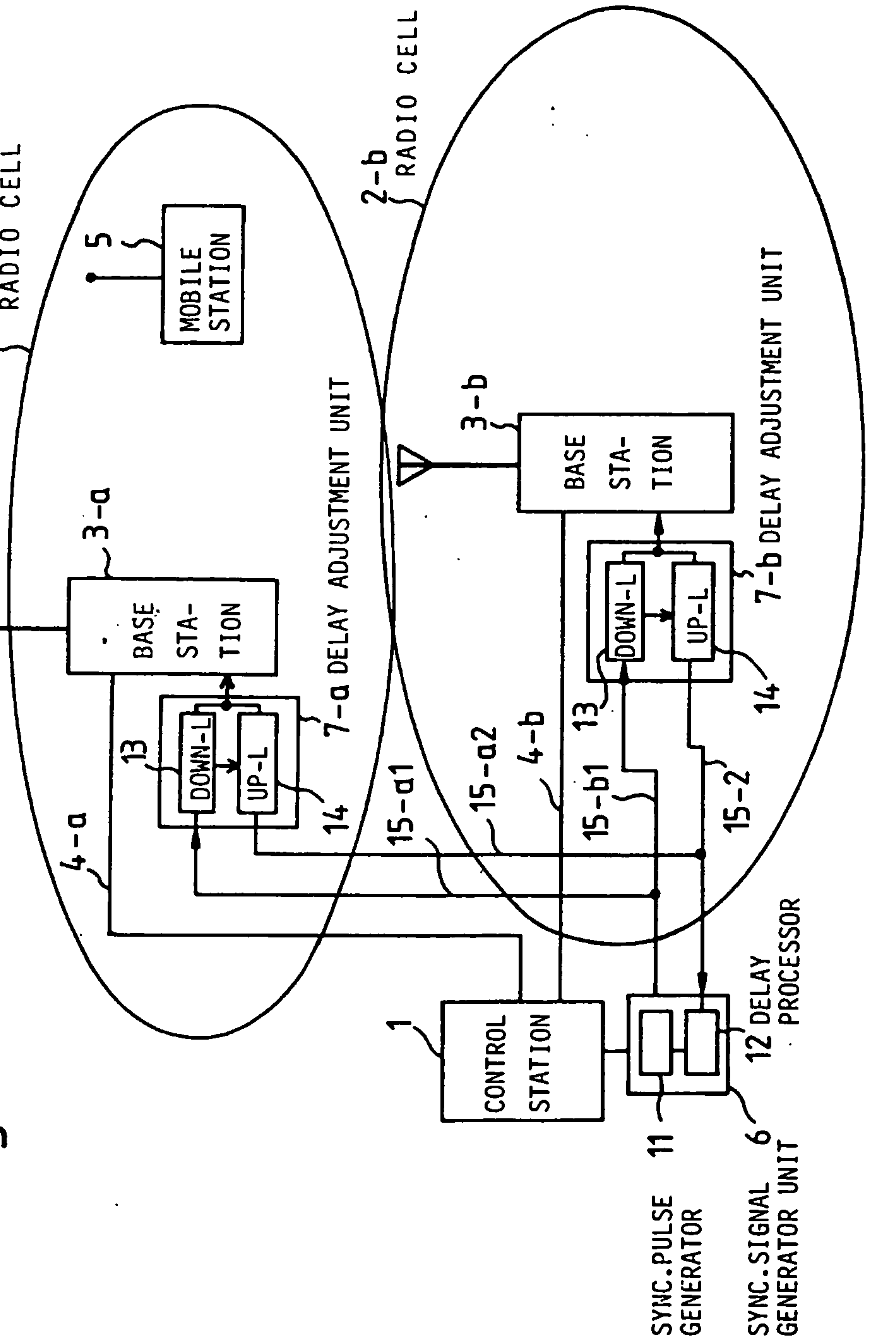

2-a RADIO CELL
2-b RADIO CELL
5
MOBILE STATION
3-a
BASE STA- TION
3-b
BASE STA- TION
7-a DELAY ADJUSTMENT UNIT
7-b DELAY ADJUSTMENT UNIT
13
DOWN-L
UP-L
14
4-a
4-b
15-a1
15-a2
15-b1
15-2
1
CONTROL STATION
12 DELAY PROCESSOR
11
6
SYNC.PULSE GENERATOR
SYNC.SIGNAL GENERATOR UNIT

Fig. 1

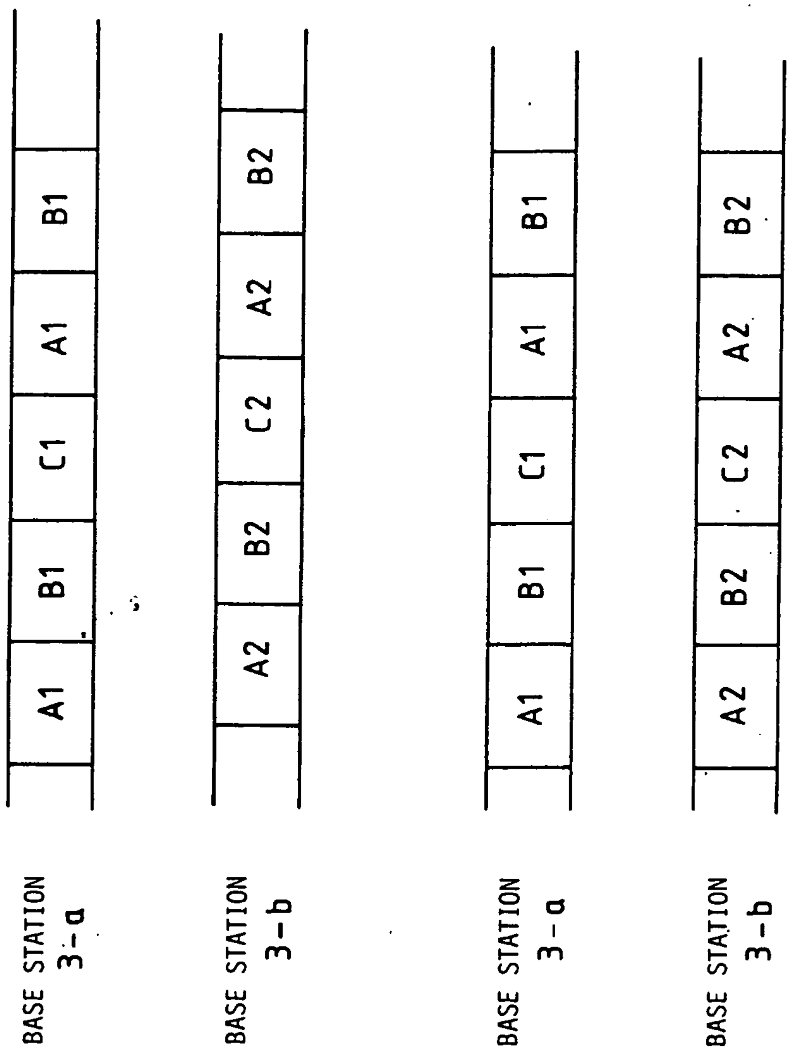
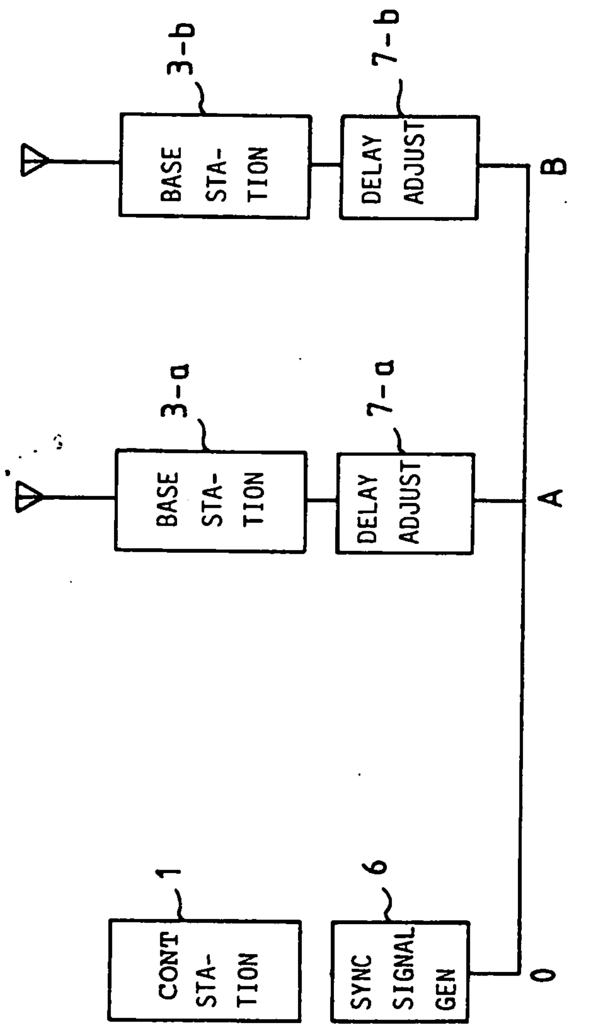


Fig. 2A B

Fig. 3A B



CONT STA- TION
1
SYNC SIGNAL GEN
6
BASE STA- TION
3-a
DELAY ADJUST
7-a
BASE STA- TION
3-b
DELAY ADJUST
7-b
0
A
B

Fig. 4

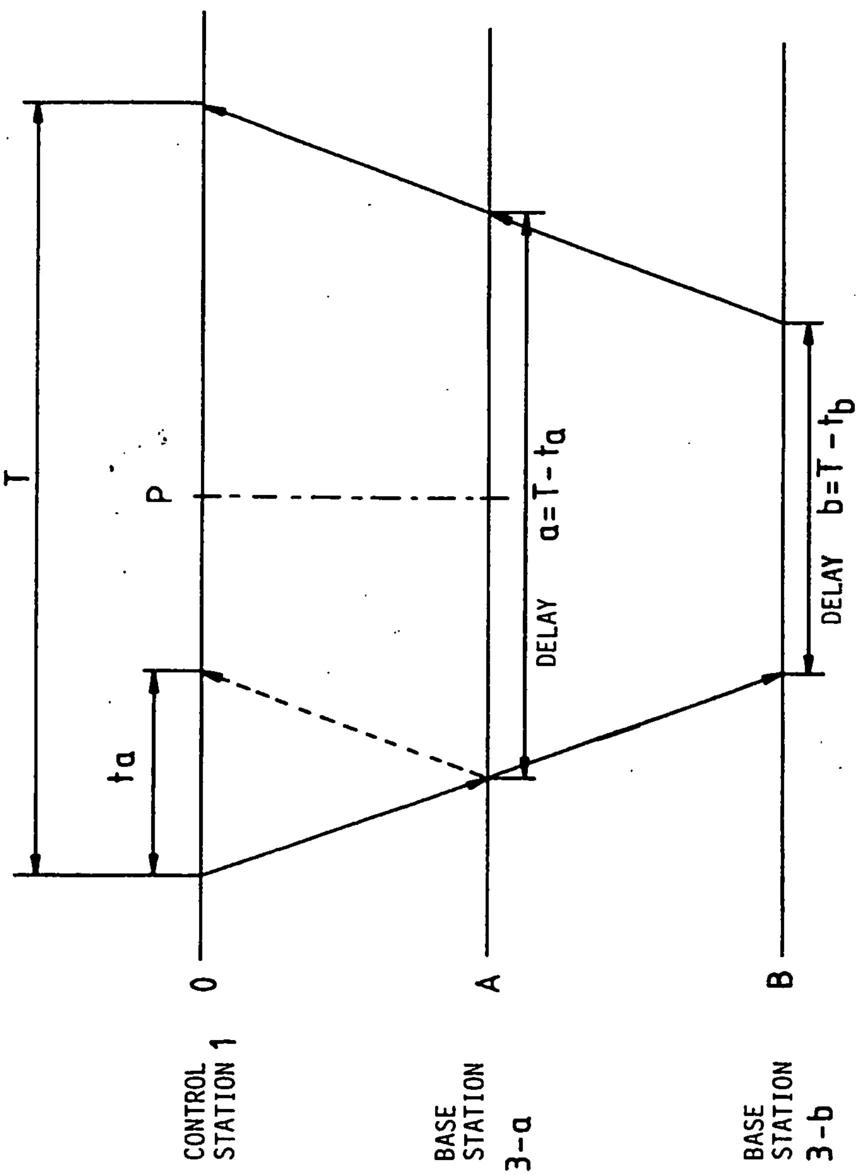

T
ta
P
a=T-ta
DELAY
b=T-tb
DELAY
0
A
B
CONTROL STATION 1
BASE STATION 3-a
BASE STATION 3-b

Fig. 5

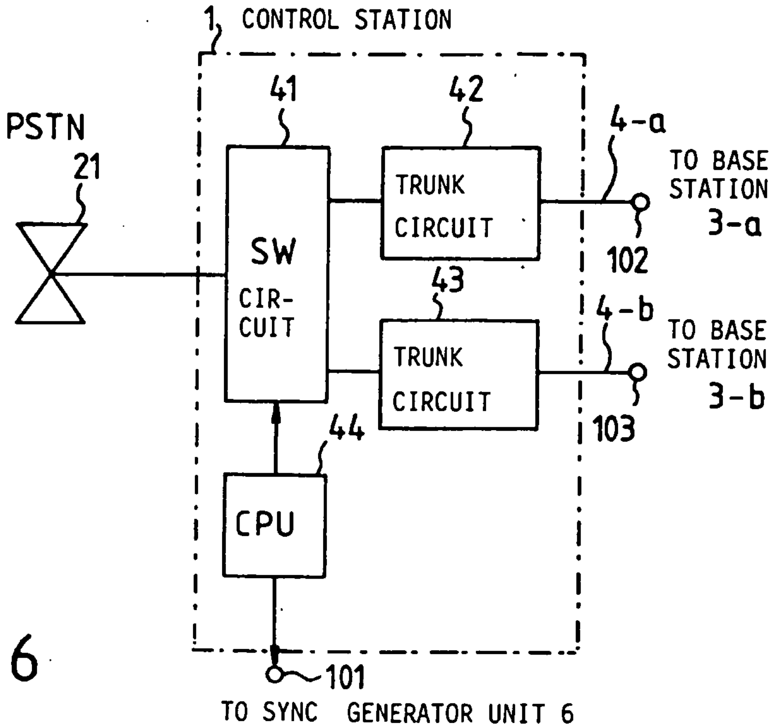

1 CONTROL STATION
41
42
PSTN
21
4-a
TO BASE STATION 3-a
TRUNK CIRCUIT
SW CIR-CUIT
102
43
4-b
TO BASE STATION 3-b
TRUNK CIRCUIT
103
44
CPU
101
TO SYNC GENERATOR UNIT 6

Fig. 6

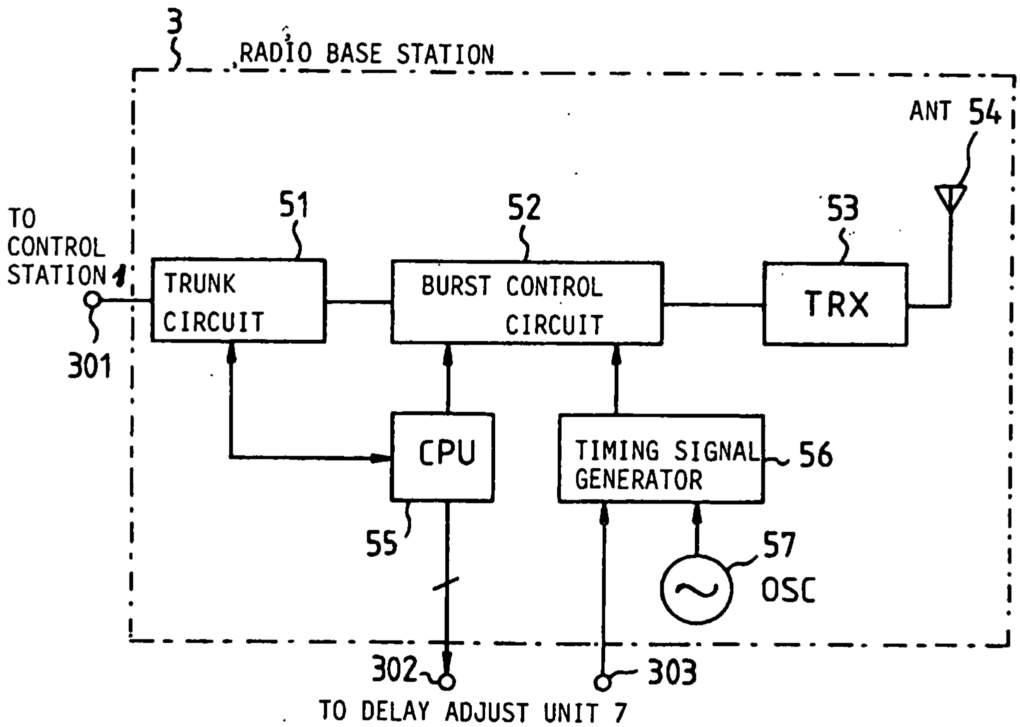

3
RADIO BASE STATION
ANT 54
TO CONTROL STATION 1
51
52
53
TRUNK CIRCUIT
BURST CONTROL CIRCUIT
TRX
301
CPU
TIMING SIGNAL GENERATOR
56
55
57
OSC
302
303
TO DELAY ADJUST UNIT 7

Fig. 8

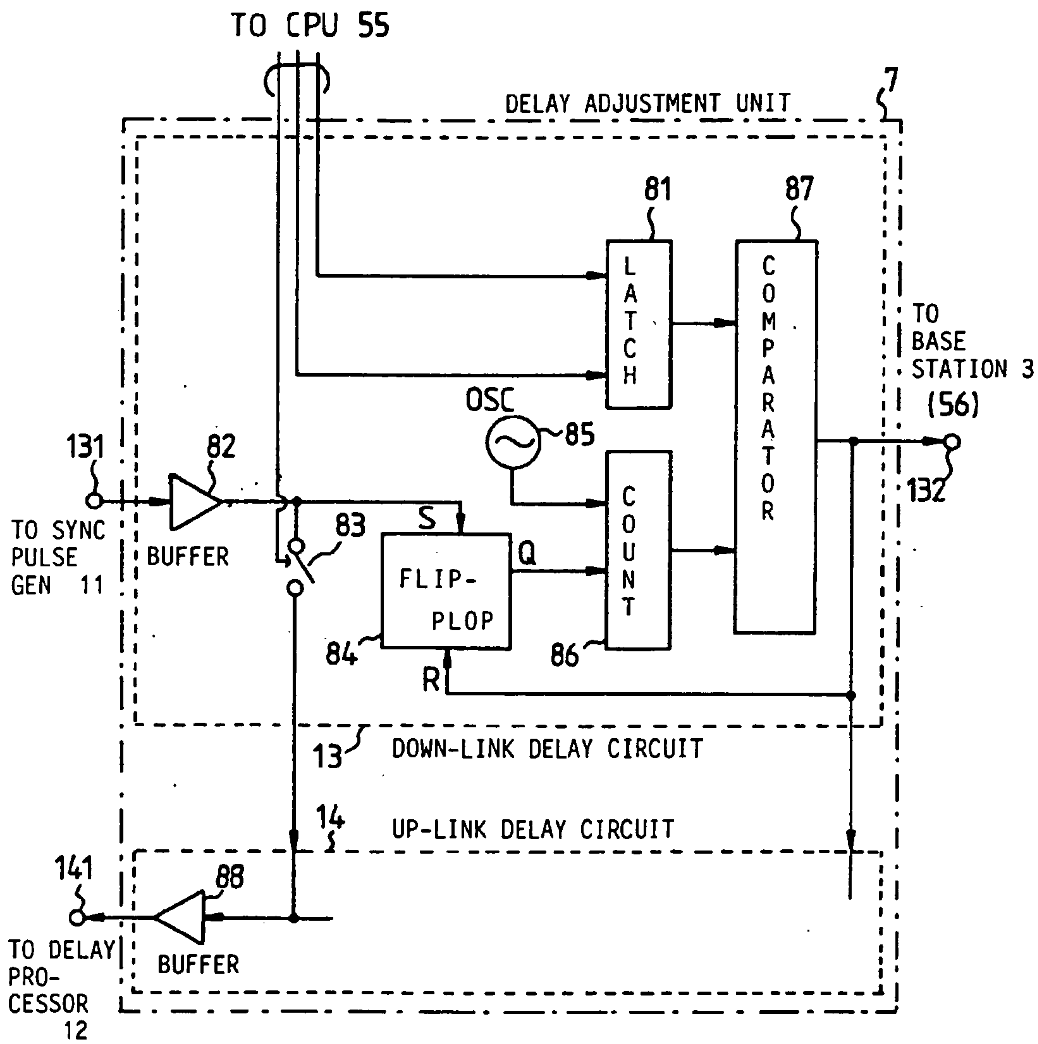
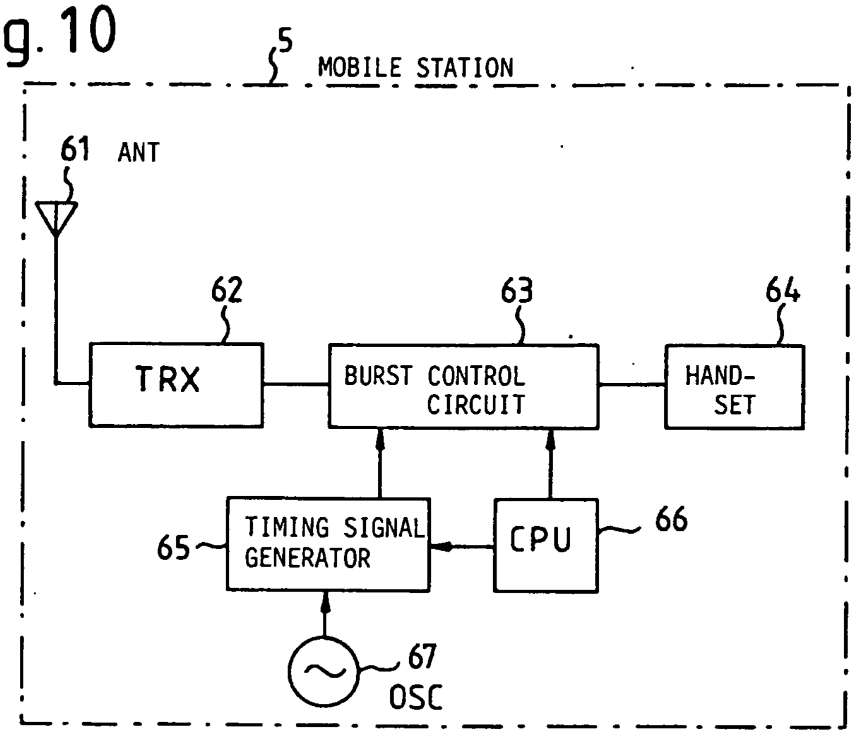

TO CPU 55
DELAY ADJUSTMENT UNIT
7
81
87
L A T C H
C O M P A R A T O R
TO BASE STATION 3
(56)
OSC
85
131
82
132
TO SYNC PULSE GEN 11
BUFFER
83
S
Q
FLIP-PLOP
C O U N T
84
86
R
13
DOWN-LINK DELAY CIRCUIT
14
UP-LINK DELAY CIRCUIT
141
88
TO DELAY PRO-CESSOR 12
BUFFER

Fig. 9

Fig. 10


5 MOBILE STATION
61 ANT
62
63
64
TRX
BURST CONTROL CIRCUIT
HAND-SET
TIMING SIGNAL GENERATOR
CPU
65
66
67
OSC

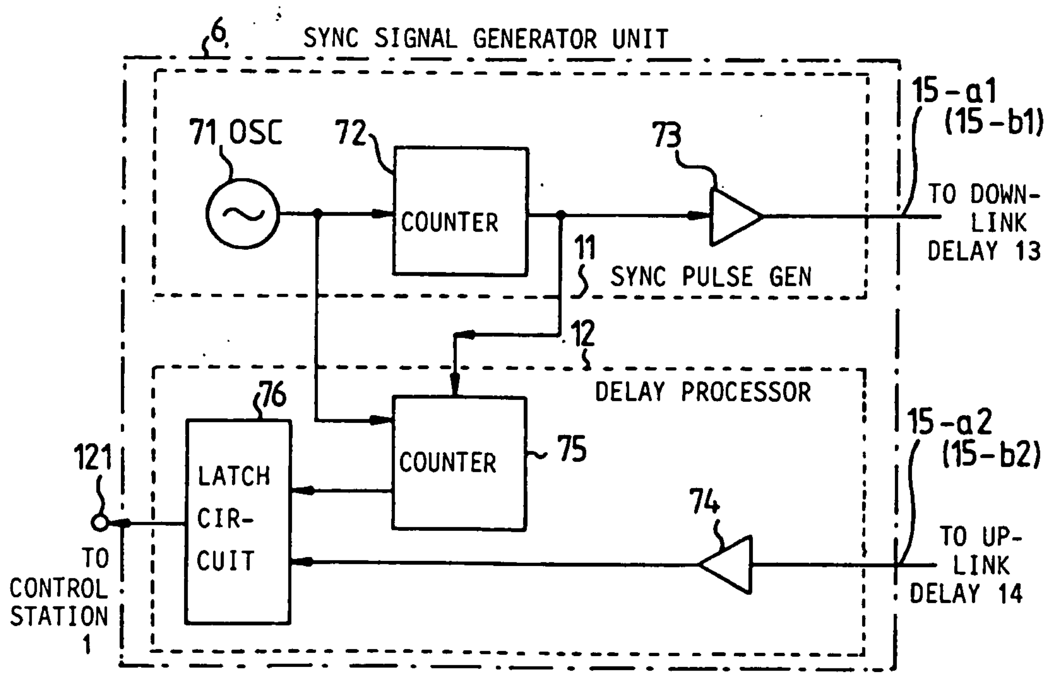

6 SYNC SIGNAL GENERATOR UNIT
71 OSC
72
COUNTER
73
15-a1 (15-b1)
TO DOWN-LINK DELAY 13
11 SYNC PULSE GEN
12
DELAY PROCESSOR
76
LATCH CIR-CUIT
COUNTER
75
15-a2 (15-b2)
121
74
TO UP-LINK DELAY 14
TO CONTROL STATION 1

Fig. 7